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ZOOLOGY.—*The evolution of the animal body.*[1] AUSTIN H. CLARK, U. S. National Museum.

In a recent number of this JOURNAL[2] I gave a brief synopsis of the steps in the evolution of animals based upon the progressively increasing complexity of structure correlated with increased economic efficiency. The subject was treated in much greater detail in a later paper.[3]

Superposed upon this evolutionary line there is another having to do with the development of the body as a whole instead of with the refinement of its internal organization, and to a large extent the two are quite independent.

All the higher animals are ultimately derived from an attached animal colony within which the component zooids are more or less differentiated for the better performance of certain more or less definite functions, this animal colony being in general comparable to the colony of phytons known as a flowering plant.

In the sponges the colonial nature of the animal is evident, but there are no definite organs or tissues, and the mass is imperfectly or not at all divided. The sponges are thus comparable to certain of the so-called thallophytes.

The coelenterates have a definite body structure and are fundamentally colonial, the colony being produced asexually by budding and the component individuals usually showing more or less differentiation into (*a*) nutritive, (*b*) reproductive and (*c*) excretionary ("defensive") types, the latter bearing numerous cells containing a secretion and also a coiled tubule. Free living coelenterates occur, and these arise (1) through the assumption of a free floating existence by the colony as a whole (siphonophores), or (2) through the partial (medusae of hydroids) or complete (*Aurelia*, Trachomedusae, most actinians, etc.) dissociation of the units of the colony.

[1] Received December 16, 1921.
[2] THIS JOURNAL 11: 207–208. May 4, 1921.
[3] Bull. de l'Instit. Océanographique (Monaco), 400: 1–24. 20 septembre, 1921.

The jointed cestodes represent the strobila stage of *Aurelia*, but are somewhat more completely unified, the proglottides sharing a common nervous and excretory system and their detachment being greatly retarded. The pronounced bilateral symmetry of most cestodes and the marked difference in the two sides of the proglottides seen in others together with certain features connected with the budding of the scolex suggest their relationship with the graptolites of which they are possibly the recent representatives.

By a further consolidation and unification of the jointed cestode body correlated with a loss of the individuality of the component segments the annelid body type was evolved, and a further consolidation gave rise to the crustaceans, within which group the tendency is to compress all of the functions of the body within the compass of a few anterior segments, and the insects, in which there are three small groups of segments each with a definite function, (*a*) the head, most unified, controlling and directing, (*b*) the thorax, less unified, locomotor, and (*c*) the abdomen, largest and least unified, enclosing the digestive, reproductive and other organs.

Most crustaceans are more or less, and many are conspicuously, asymmetrical, while in all there is noticeable a great development of the dorsal surface as compared with the ventral. Both of these features are especially characteristic of certain barnacles, become greatly accentuated in the Pelmatozoa, and reach an extreme development in the unattached echinoderms in which the body consists of five half segments only arranged in a circle and enclosed entirely by the dorsal surface, the ventral having almost completely disappeared.[4]

The evolution of solitary animals through the progressive consolidation of a colony correlated with increasing loss of individuality by the component units can thus be traced from the coelenterates through the cestodes to the arthropods and echinoderms.

Closely allied to the cestodes are the trematodes, and from them or from very similar organisms another very different line of development has arisen.

The development of the liver fluke, like that of the tapeworm, in the division of the sporocysts and the subsequent development of cercariae from sporocysts and rediae is comparable in its essential features to strobilization, but the budding takes place, so to speak, within a closed scyphistoma; that is, the sporocysts and rediae undergo

[4] Smith. Misc. Coll. 27: No. 11, 1–20. July 20, 1921.

a sort of invaginated strobilization, the larvae (cercariae, corresponding to ephyrae) finally escaping by the disintegration of the nurse.

The unsegmented cestodes bear approximately the same relation to the tapeworms that *Lucernaria* does to the scyphistoma of *Aurelia*, and the turbellarians in their relations to the liver flukes and their allies are comparable to the Trachomedusae as compared with the colonial coelenterates; that is, they are solitary animals ultimately derived through the dissociation of the units of a primarily colonial type.

Of the remaining acoelomate Eumorphozoa the Polyzoa and Calyssozoa are clearly comparable to colonial coelenterates; the rotifers in their asexual and direct development suggest a fragmented colony while the round worms and the Acanthocephala are solitary, like the Trachomedusae, some cestodes, and the turbellarians.

All other animals agree in the possession of that structure known as a coelome. The coelome, which arises by budding from the enteron, consists of three sections, (*a*) the perivisceral, forming a body cavity, (*b*) the gonadial, and (*c*) the nephridial. There is thus a curious correspondence between the three divisions of the coelome and the three classes into which the polyps of the coelenterates naturally fall, and this suggests the possibility of coelomate animals having arisen through a gastruloid structure resembling a redia by the budding off from the enteron of three units which remained within the gastruloid and there became differentiated into the three types characteristic of the externally budded coelenterate polyps, subsequently undergoing further development.

The priapulids, sipunculids, molluscs, nemerteans, phoronids, brachiopods, chaetognaths, enteropneusts, tunicates, cephalochordates and vertebrates would thus be explained as colonial animals derived from a coelenterate-like colonial type through a process of invagination by which the additional units were produced within the original gastruloid ancestor by budding from the enteron instead of externally as in the coelenterates and polyzoans.

Such an interpretation would account for (1) the entire absence in these groups of that external segmentation so characteristic of the cestodes, the annelids, the arthropods and the echinoderms; (2) the entire absence, except in the enteropneusts and tunicates, which stand quite apart from the other phyla, of all forms of asexual reproduction, this being here represented by internal budding; (3) the almost complete absence of parasitism (occurring only in a very few molluscs and nemerteans), since the transference of the asexual bud-

ding to the interior prevents that prolific asexual reproduction by budding and fission, by parthenogenesis, or by polyembryony always present in those groups in which parasitism is a prevalent condition; and (4) the almost complete absence of attached forms which, except for secondarily attached molluscs, are found only among the brachiopods and the tunicates.

The annelids, in addition to their dominant external segmentation, also possess a coelome, but this becomes greatly reduced in the crustaceans and insects. In the echinoderms, however, the curious distortion leads to a relatively considerable average length for each of the five segments represented, and with this annelidan feature the coelome reappears in a highly perfected form.

The development of the annelids indicates a very close relationship with the molluscs. These two groups thus carry onward the essential differences, as well as the essential similarities, between the cestodes and the trematodes. Similarly the arthropods and the echinoderms appear to be structurally parallel to the nemerteans, phoronids, brachiopods and chaetognaths, the former representing the cestode-annelid, the latter the trematode-priapulid-sipunculid-mollusc type.

The enteropneusts, the tunicates, the cephalochodates (*Amphioxus*, etc.) and the vertebrates are quite unrepresented in the externally segmented line, which culminates in the arthropods and echinoderms. They differ from all other animals in the possession of gill slits or pores. These structures represent the final step in the organization and centralization of the respiratory function and its connection with the endoderm. This is obviously a minor structural detail, presumably of late origin, and as such it suggests that while the other major animal types probably all appeared almost or quite simultaneously the evolution of the forms with gill apertures was considerably delayed.

GEOPHYSICS.—*The latitude of Ukiah and the motion of the pole.*[1] WALTER D. LAMBERT, U. S. Coast and Geodetic Survey.

In January, 1921, Professor A. C. Lawson of the University of California published an article on earth movements in California.[2]

[1] Presented before the Philosophical Society of Washington, November 19, 1921. Received December 7, 1921. The substance of this paper was also presented at a meeting of the American Astronomical Society at Swarthmore, Pa., December 29, 1921. This paper is based on a longer article by the author entitled *An investigation of the latitude of Ukiah, California, and of the motion of the Pole*, which will appear as a Special Publication of the U. S. Coast and Geodetic Survey.

[2] *The mobility of the Coast Ranges of California, an exploitation of the elastic rebound theory.* Univ. Calif. Publ., Bull. Dept. Geol. **12**: No. 7. Jan. 11, 1921.

His thesis is that there are slow movements of the surface as a result of stresses arising from a subcrustal flow that carries the surface with it. In time these stresses increase to the breaking point; there is then rupture with attendant seismic shocks and a rebound toward the original position.

In support of this thesis Professor Lawson adduces the triangulation executed by the Coast and Geodetic Survey[3] in California at various times before the earthquake of 1906 and during the months immediately following. He adduces also the observed astronomic latitudes at the Ukiah latitude station, one of the stations of the International Latitude Service maintained for the study of the variation of latitude and the motion of the Pole. It should be stated that Ukiah lies outside of the area that was treated as potentially movable in the discussion of the triangulation. The line of greatest disturbance during this earthquake runs along the San Andreas fault; the nearest point of this fault is some 30 miles from Ukiah and not far from the point where the fault itself runs out to sea in a northwesterly direction.

It is not the purpose of this paper to interpret the evidence from the triangulation, but solely to consider the meaning of the astronomic latitudes at Ukiah, which constitute a problem quite independent of the problem presented by the triangulation.

The latitude of Ukiah appears to be increasing with some regularity at a rate not much smaller than 0.01 second per year, that is, a displacement of almost 1 foot or 30 cm. per year. This deduction was made by Professor Lawson from curves given in an article by Sir Frank Dyson,[4] Astronomer Royal of England. It should be said that the curves are used by Dyson for quite a different purpose, and that this increase in latitude is not mentioned by him, nor would its existence affect his results to any perceptible degree. It should be said on the other hand that an apparent increase of this sort is very evident from a mere inspection of the curve for Ukiah, which is shown in figure 1.

As is well known, the two principal periodic terms in the expression for the variation of latitude have periods of one year and of about 14 months. The curve shows the observed variation of latitude with the effect of the annual term removed by computation. The annual term was deduced by harmonic analysis from the observed latitudes at Ukiah only and is therefore independent of any assumption as to the

[3] J. F. HAYFORD and A. L. BALDWIN, *The earth movements in the California earthquake of* 1906. U. S. Coast and Geod. Surv. Ann. Rept. **1907**, App. 4.

[4] F. W. DYSON. Month. Not. Roy. Astr. Soc. **78**: 452. 1918.

motion of the Pole other than the mere lengths of the periods concerned.

If the variation of latitude conformed to the simplifying assumptions that we often make, the curve would be a simple sine curve with constant amplitude and with its phase changing at a uniform rate. There is, however, a marked increase in the amplitude although the phase change is nearly uniform. The ordinate represents, not the observed latitude itself, but the difference, $\Delta\phi$, between the observed latitude and an arbitrary but fixed initial latitude. The initial latitude is such that near the beginning of the period this conventional zero line of $\Delta\phi$ coincides very nearly with the true zero line, or line running midway between the points of maximum and minimum. Towards the end of the period the curve has shifted so much that most of it lies above the conventional zero line. The angle between the true zero line and the conventional zero line represents the rate of increase of the mean latitude, that is, of the latitude freed from the effects of all known periodic terms. This slope or rate Professor Lawson determined by a graphic adjustment; he drew a straight line passing as near as possible

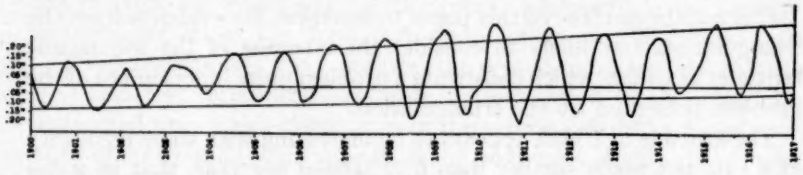

Fig. 1. The latitude of Ukiah, California, from Dyson's curves, with lines drawn by Lawson to show the progressive increase of latitude.

to the maxima of the curve and a similar line for the minima, and then drew a line bisecting the angle between the two lines just found. This bisector may be taken as representing the true zero line.

The slope of this true zero line referred to the conventional one is, as found by Professor Lawson, 0″.0094 or 0.29 meter a year. His method does not use all the information afforded by the curve, but merely the maxima and minima; the lines drawn to fit these are necessarily affected by personal idiosyncrasies. The following method is free from these objections.

The curve supposedly contains only the effect of the 14-month component and of a possible progressive shifting of the zero line. The former effect will be eliminated from the mean of 14 successive calendar months,[5] leaving in the mean only the progressive shift

[5] The exact period is 432.5 days rather than 14 calendar months (426 days), but the error arising from the substitution of one period for the other is negligible.

of the zero. Table 1 shows the result of taking these means. They are also shown graphically in figure 2.

Instead of adjusting a straight line to the means by eye we may do it by the method of least squares. The observation equations would then be written in the form

$$\Delta\phi = x + yt,$$

TABLE 1.—MEAN VALUE OF $\Delta\phi$ FOR UKIAH

Middle of 14-month period	Mean $\Delta\phi$	Middle of 14-month period	Mean $\Delta\phi$
1900, Aug. 1	+0".001	1908, Oct. 1	+0".047
1901, Oct. 1	−0 .040	1909, Dec. 1	+0 .058
1902, Dec. 1	+0 .001	1911, Feb. 1	+0 .070
1904, Feb. 1	+0 .047	1912, Apr. 1	+0 .063
1905, Apr. 1	+0 .054	1913, Jun. 1	+0 .055
1906, Jun. 1	+0 .068	1914, Aug. 1	+0 .118
1907, Aug. 1	+0 .066	1915, Oct. 1	+0 .152

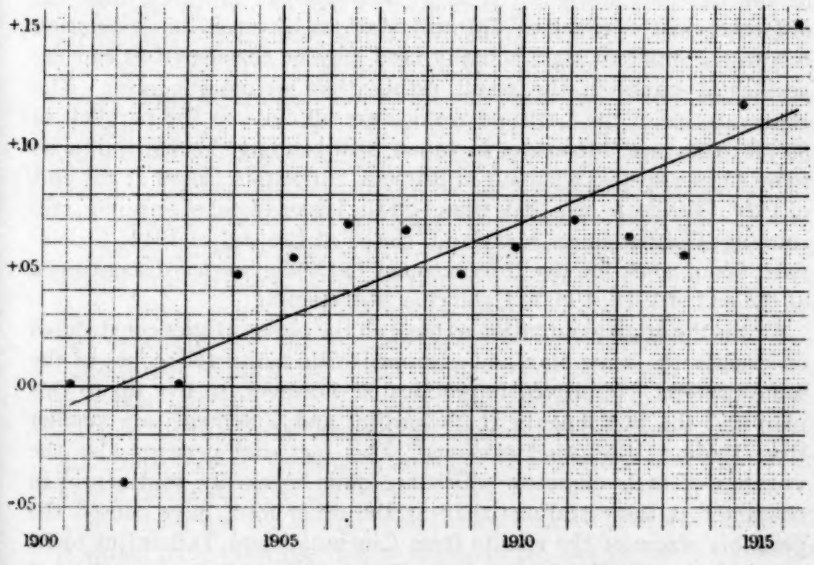

Fig. 2. The latitude of Ukiah, California, means by 14-month periods and line showing adjusted rate of increase; derived from Dyson's curves.

where t is the time reckoned from some convenient epoch, x is the adjusted value of $\Delta\phi$ at the epoch, y is the adjusted rate of change of the mean latitude, and the $\Delta\phi$ represents one of the values of $\Delta\phi$ in the table. The result of the adjustment gives for the equation of the

true zero line

$$\Delta\phi = +0''.0590 + 0''.0081t,$$

where t is the time in years reckoned from the epoch, Oct. 1, 1908. This line is the one shown in figure 2. The slope $+0''.0081$, with a probable error $\pm 0''.0010$ per year, is somewhat smaller than the $+0''.0094$ found by Professor Lawson but still quite large enough to be of interest, and if taken at its face value, it is large enough to render probable Professor Lawson's thesis of a northward movement of the superficial crust at Ukiah.

Before reaching definite conclusions in the matter it is desirable to see what is happening at the other stations of the International Latitude Service. These stations all use the same program of stars and any errors in the declinations used affect all stations alike except insofar as bad weather may cause the stars observed to be different at the different stations. It is to be supposed, however, that the difference in the effect at different stations of errors in declination due to the different stars actually used may be considered as causing accidental errors in the result rather than systematic ones. The observatories of the Latitude Service are all close to the parallel[6] of 39° 8′; they are: Mizusawa in Japan, still running; Tschardjui (or as more simply spelled Charjui) in Russian Turkestan, closed at the end of 1914; Carloforte on a little island off the larger island of Sardinia, still running; Gaithersburg, Maryland, closed at the end of 1914; Cincinnati, Ohio, work for the International Latitude Service discontinued at the end of 1915; Ukiah, California, still running.

It was the original intention to have all the observatories constructed on exactly the same plan and equipped with zenith telescopes of the same pattern. It proved impracticable, however, to live up to this plan and the instruments at Tschardjui and Cincinnati are smaller than those at the other stations. This fact and perhaps also the vagaries of their climates, which are more markedly continental in character at these stations than at the other four, have caused the probable errors of the results from Cincinnati and Tschardjui to be relatively large. Furthermore, the Tschardjui results are complicated by the removal of the observatory in 1909 to a new location, a removal forced by the wanderings of the Amu Darya River, the ancient Oxus. The old site was threatened and finally inundated and the latitude connection between the old and new sites is rather weak. All these

[6] For longitudes see table 2 on p. 36

circumstances combined have made the results at Tschardjui relatively so inaccurate that they have very little weight in the final results of this discussion. To a less degree the same holds good of Cincinnati. The observations at the four remaining stations are about equal in quality.

Sir Frank Dyson did not give curves like that at Ukiah for all the six stations and there appeared to be some uncertainty about the declinations used in the latter part of the period that he treats, a matter important for the present purpose but not very important for his purpose, so it was decided to start afresh and to derive curves for all six stations, utilizing all the observed latitudes available; these extended from 1900 through 1917, a year beyond the time covered by Dyson. The new curves were based on the definitive latitudes of the International Latitude Service[7] and the provisional results published from time to time in the *Astronomische Nachrichten*.[8] These results are all on a common declination system, that of Vol. 3 of the *Resultate*, not the ideal system perhaps, but one consistent with itself. On account of the precession some of the stars necessarily drop out of a star program as time goes on. In the provisional results these discontinued stars have not been replaced by others. The provisional results therefore depend on a smaller number of stars, thus reducing the weight of the results to about $^5/_6$ of that of the definitive ones.

The latitudes of the several stations were plotted, curves were drawn to smooth out the worst roughnesses in the plotted values, and these curves were analyzed harmonically to obtain the amplitudes and epochs of both the annual and the 14-month components. Each station was treated by itself. Some refinements not found in all harmonic analyses were introduced and seemed to justify their introduction by the better agreement thus obtained between the various determinations of the same quantity. The details will be given in my longer publication on the subject.

By taking out the annual term from the curve of observed latitudes it would have been possible to draw curves like Dyson's, containing, presumably, only the effects of the 14-month term and of a possible shift in the true zero line. At least, if other effects were present, they would be treated as accidental errors. By reading these new

[7] Zentralbureau der Internationalen Erdmessung (Berlin). *Resultate des Internationalen Breitendienstes.* **3:** 1909. **5:** 1916.

[8] Astr. Nachr. **198:** No. 4749. 1914. **201:** No. 4802. 1915. **203:** No. 4855. 1916. **206:** No. 4908. 1917. **208:** No. 4969. 1918.

curves at uniform intervals and taking the mean of the readings over a period of 14 months, the effect of the 14-month term would be made to

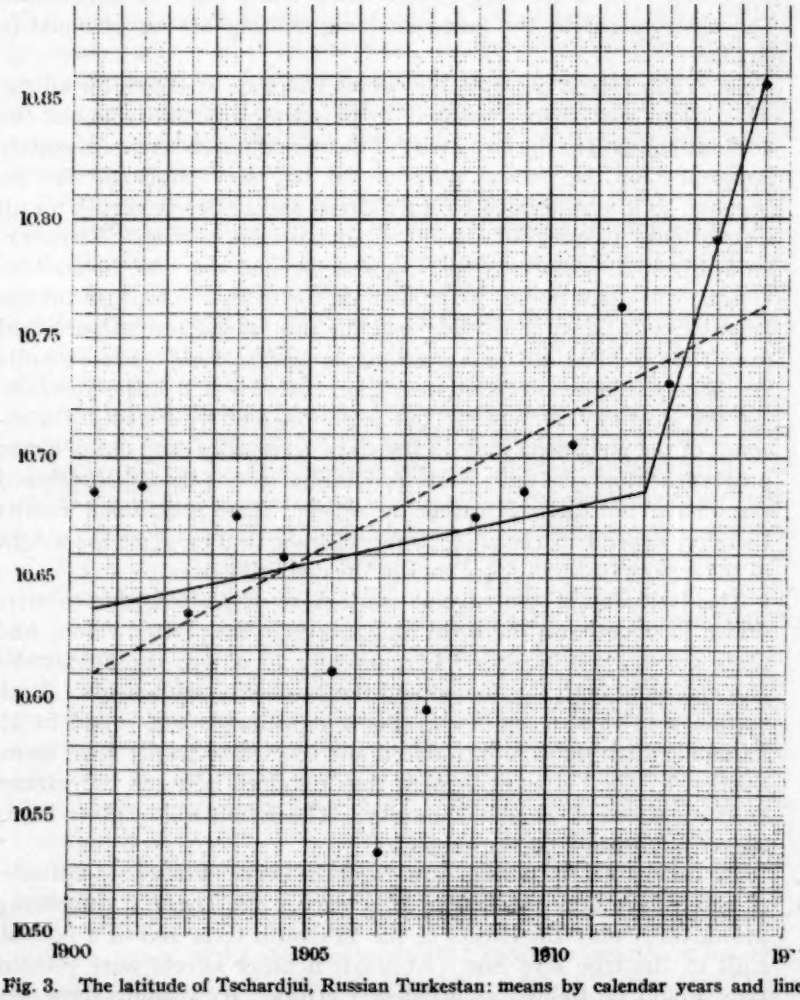

Fig. 3. The latitude of Tschardjui, Russian Turkestan: means by calendar years and lines showing adjusted rates of change; derived from the latitudes of the International Latitude Service.

disappear from the mean, leaving only the effects of a shifting of the zero line, that is, of a progressive change in the mean latitude.

It would be equally legitimate to interchange the processes by which the two periodic portions of the latitude variation were eliminated. Instead of taking out the effect of the annual portion by computing from an assumed expression for it in the form of an harmonic term, we could take out the 14-month component by assuming it to be expressed by a harmonic term and computing the necessary values. The remaining periodic portion of the variation would be the annual portion and could be eliminated by taking means over the period of a year. These means, being free from the effects of periodic terms, should bring to light the progressive variation.

Both methods were employed and the two rates thus obtained for the progressive change of latitude at a station agreed well in all cases. There appeared to be some reason for thinking that the rate of change might be different for the later years; with this in mind the experiment

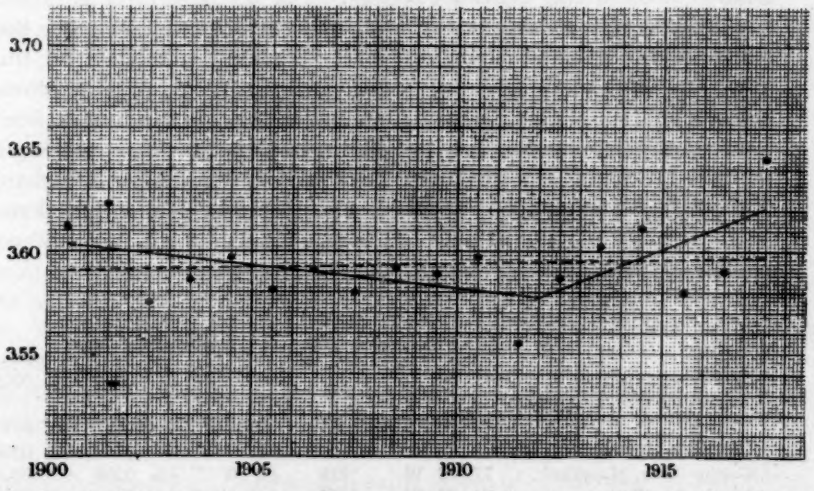

Fig. 4. The latitude of Mizusawa, Japan; means by calendar years and lines showing adjusted rates of change; derived from the latitudes of the International Latitude Service.

was tried of fitting two straight lines to the mean latitudes instead of only a single line, the two lines to show the same latitude at a predetermined epoch. This epoch was taken not far from the end of 1911. The considerations governing this choice were in part the general appearance of the plotted mean latitudes and in part the change in the star program at the end of 1911 already referred to and due to the dropping of certain stars.

The closeness of the fit of the two lines or of the single lines may be judged from figures 3 and 4. Figure 3 shows the results for Tschardjui, the means being taken by calendar years. It has been said that this station has been subject to great irregularities and this appears plainly from the diagram. The only thing that clearly appears is a tendency for latitudes to increase very sharply towards the end of the period. Figure 4 shows Mizusawa, perhaps the most regular station, though the other stations except Tschardjui and Cincinnati are not greatly inferior to it. Even the most regular of stations shows considerable departure from a perfectly uniform progressive increase, although the irregularity is somewhat exaggerated to the eye by the large vertical scale used for the latitudes. The probable error of the mean of a single year or of a single 14-month period is about $\pm 0''.010$ at Mizusawa as determined from the residuals arising from attempting to fit the two straight lines to the successive means. The probable error is rather larger when only a single line is used, a fact which tends to prove the reality of the assumed change in rate. Similar results hold for the other stations except Tschardjui and Cincinnati, the probable errors being about $\pm 0''.015$ for the two lines and about $\pm 0''.018$ for one line.

The mean rates of increase are shown in table 2. They represent the mean results of the two methods of procedure already referred to, mean latitudes being taken by calendar years and by 14-month periods. The fitting of the straight lines to the means was done by the method of least squares.

TABLE 2.—MEAN ANNUAL RATES OF CHANGE OF LATITUDE

Station	Longitude	Observations end with year	Annual rates of change 1900–11	1912–end	1900–end
Mizusawa, Japan	141° 08′ E	..	$-0''.0025$	$+0''.0096$	$+0''.0008$
Tschardjui, Russian Turkestan	63 29 E	1914	$+0''.0036$	$+0''.0597$	$+0''.0115$
Carloforte, Sardinia	8 19 E	..	$+0''.0002$	$+0''.0182$	$+0''.0053$
Gaithersburg, Maryland	77 12 W	1914	$+0''.0087$	$+0''.0206$	$+0''.0105$
Cincinnati, Ohio	84 25 W	1915	$+0''.0029$	$+0''.0404$	$+0''.0099$
Ukiah, California	123 13 W	..	$+0''.0075$	$+0''.0194$	$+0''.0106$

The first two columns under the general heading "Annual rates of change" give the slopes or rates of change of latitude when two lines are used. The last column gives the slope when only one line is used. The rate of change may vary with the period of time covered so that only in the first column are the rates for all stations strictly comparable with one another. In the second and third columns the rates of Mizusawa, Carloforte, and Ukiah are comparable in this way. The

rates in the second column, particularly the rates of stations now discontinued, depend on only a few mean latitudes, and offer only an insecure basis for conclusions.

The rates of change at Ukiah are not very different from the rates found from Dyson's curves, namely, +0".0094 by Lawson and +0".0081 by the author.[9] The striking fact, however, is that a rate of this size is no longer a solitary phenomenon. There are many rates of this order of magnitude and with one exception all rates are positive.

Before seeking an explanation I think it will be wise to rule out the results for Tschardjui altogether. If results were weighted according to their probable errors, the Tschardjui results would get weights only from 1/10 to 1/20 as large as those of other stations, and would thus have little effect on our final conclusions.

We might explain the positive rates at all stations by a northward creep of the surface strata, as Professor Lawson has done for Ukiah, but such an explanation is scarcely satisfactory when it must be made to apply to so many stations. A better partial explanation is *declinations*. The so-called observed latitudes are also computed ones to a certain extent, and errors in the declinations of the stars used appear with practically full effect in the so-called observed latitudes. It would appear from the table as if the average declinations became increasingly erroneous with the lapse of time; an error of this kind would naturally be looked for in the adopted values of the proper motions. But even an error in the proper motions and the consequent declinations does not explain all the rates in the table. An error in the star places would affect all stations alike, except insofar as bad weather might cause the stars actually observed to vary from station to station. It is clear that latitudes are increasing much faster on the American continent than elsewhere, and for a while in the opposite quarter of the world, as at Mizusawa from 1900 to 1911, they were actually decreasing. An obvious explanation of an increase in latitude on one side of the earth accompanied by a decrease in the other is a shifting of the Pole.

I believe that the explanation of the changes of latitude set forth in the table will be found in a shifting of the Pole combined with an increasing error in the declinations. This hypothesis may be tested by a least-square adjustment. Let u and v denote the components

[9] The number in the table most nearly corresponding to the result for Ukiah found from Dyson's curves is the +0".0106 in the last column. The difference is probably due in great part to the declination system used. See below.

of the assumed annual shift of the North Pole towards the Equator along the meridians of Greenwich and of 90° W, respectively; let w denote the annual increase in latitude common to all stations and due to erroneous declinations; then the observation equations have the form

$$u \cos \lambda + v \sin \lambda + w = \text{observed annual rate},$$

where λ is the west longitude of the station in question.

Various least-square solutions were tried with different weights for the several stations and different sets of annual rates. Full details will be given in the longer publication. The results were fairly consistent and the adopted result was a motion of the North Pole southward along the meridian of 77° West of Greenwich at a rate of about 0″.0050 a year. The values of w depend on the star program and represent mean cumulative corrections to the declinations for the period covered; they might therefore be expected to differ according to the set of rates used, even if the components of the polar motion remained constant. This was found to be the case, the values of w ranging from +0″.0013 to +0″.0050.

This then is the interpretation I would offer of the apparent increase in latitude at Ukiah; cumulative errors in the declinations combined with a shifting of the North Pole towards the American continent. There might be also the surface creep which Professor Lawson offers as the all-sufficient explanation, but I believe that if this creep exists, its contribution to the increase in latitude is quite subordinate to the contributions of the other causes.

The suggestion of a displacement of the Pole towards the American continent has been made before. Wanach,[10] the successor to Albrecht in the work of the International Latitude Service, found from the observations of the Service from 1900 to 1911, inclusive, a displacement of the North Pole at the rate of not more than 0″.0030 a year and in the general direction of Newfoundland, say along the meridian of 56° West. The period of time covered is different, likewise the method of treatment and the weights assigned to Tschardjui and Cincinnati. The differences doubtless explain the differences in the results, differences not particularly large in view of the difficulties of the subject.

It is evident that the burden of proof for this explanation of the change of latitude at Ukiah by a shifting of the Pole rests chiefly on the results at Gaithersburg, for Ukiah is suspected of being on unstable

[10] B. WANACH. *Resultate des Internationalen Breitendienstes* **5**: 219. 1916.

ground and Cincinnati is subject to a large probable error. A little consideration will show, however, that an explanation of the kind supposed that is numerically adapted to fit Gaithersburg as well as the other stations except Ukiah must be a passable fit for Ukiah also.

The deduced shifting of the Pole must be considered as limited to the period discussed, the years 1900–1917, inclusive. No examination has been made of earlier records to see whether such a shifting might have taken place in the past, and until the causes of such a shifting have been found it is unwise to predict the future. In regard to the past, it is interesting to note that a polar shifting of this sort and about this magnitude might have gone on during the whole historical period without changing the climate perceptibly. If we put the historical period at 10,000 years in round numbers, the maximum change of latitude during that time is less than a mile. It might perhaps be possible for a change of this particular sort, namely along the meridian of 77° West, to have gone on since the beginning of modern astronomy of precision—say since Bessel's time—without being noticed, simply because the longest series of accurate records are in central or western Europe, regions which are on meridians nearly at right angles to the line of displacement and which therefore undergo a relatively small change of latitude.

It is of interest to consider the possible causes for such a displacement of the Pole. A little calculation shows that the shifting of mass due to erosion and deposition of all sorts, even on the most favorable hypotheses, is quite insufficient to produce a shifting of 0″.0050 a year in the direction of the earth's axis within its mass. Theories postulating large departures of the Pole from its present position have been much in favor with certain geologists but seem fantastic to mathematicians and astronomers. An interesting criticism of these theories is to be found in an article by the late Professor Barrell.[11] The classic paper on this subject from the mathematical point of view is by Darwin.[12] A shifting of the Pole may be brought about by widespread though slight elevations and subsidences of the Earth's crust. On the most favorable assumption that seemed in any way plausible from a geological point of view, Darwin found a possible displacement of from 1° to 3° in any one geological period. The term "geological period" is conveniently vague as a unit of time, but if we take a geolog-

[11] J. BARRELL. *The status of the hypothesis of polar wanderings.* Science **40**: 333. 1914.

[12] G. H. DARWIN. *On the influence of geological changes on the Earth's axis of rotation.* Phil. Trans. Roy. Soc. Lond. I. **167**: 271. 1877. Or *Scientific Papers* **3**: 1.

ical period as meaning a million years,[13] which corresponds to one estimate of the duration of the entire glacial epoch, including all the various periods of glaciation and the interglacial periods between them, then a shift of 0″.0050 a year would mean a change of 1° 23′ in the position of the Poles during the glacial epoch, a quantity within Darwin's limits.

Now the fact that the shifting of the North Pole towards the American continent appears to have continued for the 18 years from 1900 to 1917, inclusive, does not oblige us to suppose that it has continued in the past or will continue in the future. Indeed, very recent observations at Ukiah would indicate, if taken at their face value, that the mean latitude of Ukiah is decreasing, that is, that the Pole is moving back again. No satisfactory conclusions can be reached, however, until the observations at the other latitude stations become available. There is some evidence of certain periodic effects in the variation of latitude other than those represented by the annual and the 14-month terms, effects whose periods are three years or more and which may be connected with the periods of the still obscure meteorological and climatic cycles. The shifting of the Pole may represent chiefly the combined effect of meteorological causes running their courses in periods of a few years or a few decades and be due only in very small part to elevations or subsidences of the crust.

Some of the by-products of the investigation may now be mentioned. The calculations necessary to derive the foregoing conclusions were quite extensive and made it possible to obtain with but little additional labor other results of interest in connection with the general problem of the variation of latitude. Fuller details will be given in the larger publication already referred to.

An examination was made with a view to detecting terms in the variation with periods of three and six years. Terms of these periods in the distribution of barometric pressure over the earth were found by Angenheister;[14] the magnitudes of the fluctuations of pressure appeared to be probably sufficient to affect the motion of the Pole perceptibly. Harmonic constants were deduced from the observations

[13] Cited by M. P. RUDZKI in his *Physik der Erde* (Leipzig, 1911), p. 552, as the estimate of PENCK and BRÜCKNER for the duration of the glacial epoch.

[14] G. ANGENHEISTER. *Über die dreijährige Luftdruckschwankung und ihren Zusammenhang mit Polschwankungen.* Nachr. kön. Ges. Wiss. Göttingen, Math-phys. Kl. 1914: 1. The paper is described as a preliminary communication but nothing further from Angenheister on the subject has come to the author's attention.

for terms of these periods, but the amplitudes and epochs thus found differed considerably according to stations used and the period of time covered by the observations. Probably there are perceptible terms of this sort, but the mathematical expressions for them are still quite uncertain.

Expressions in harmonic form were found for the annual portion of the polar motion and of the Kimura term. For corresponding periods of time these expressions were in excellent agreement with similar expressions deduced by the International Latitude Service, although the methods of deduction were quite different.

Similar expressions in harmonic form were found for the 14-month portion of the motion of the Pole. In deducing these terms the motion of the pole of rotation was not assumed to be uniform and circular, as it would be if changes in position of the pole of figure were strictly periodic and if the two principal equatorial moments of inertia of the Earth were equal. If, however, the assumption of uniform circular motion is made in this discussion, as it is in the work of the International Latitude Service, the expressions for the 14-month motion of the Pole agree well with the corresponding ones deduced by the Latitude Service, in spite of the difference in methods. Without the assumption of circular motion the observations always give an elliptical 14-month path for the Pole, but one so nearly circular that the exact direction of its major axis is not very certain. The major axis should coincide in direction with the meridian of the larger principal equatorial moment of inertia[15] if there is any perceptible difference in the principal equatorial moments, and it is for this reason that it is of interest to determine the position of the major axis of the ellipse of polar motion. Wanach of the International Service speaks discouragingly of the results obtained,[16] but in the present investigation the results for different six-year periods show a fair degree of agreement, perhaps

[15] This statement is subject to a correction for the effect of the yielding of the ocean waters to the forces arising from a change in position of the Pole. If the ocean covered the Earth, its yielding would prolong the period of the latitude variation as compared with that of an otherwise similar earth without an ocean, but the position of the major axis of the ellipse of polar motion would be the same for both earths. On account of the unsymmetrical distribution of land and water on the actual Earth the position of the axis of the ellipse of polar motion is affected, but the amount of the correction appears not to be sufficient to change the general character of the observed results. The subject has been investigated by A. BRILL in his doctor's thesis entitled *Über die Elastizität der Erde* (Göttingen, 1908). His conclusions do not appear to be in a form immediately applicable to the problem in hand. The question is being further investigated.

[16] *Resultate des Internationalen Breitendienstes.* 5: 220, footnote.

on account of the refinements in harmonic analysis already referred to. In table 3 λ is the west longitude of the meridian along which the major axis lies.

TABLE 3.—DIRECTION OF THE MAJOR AXIS OF THE ELLIPSE OF POLAR MOTION (432.5 DAY PERIOD)

Years, inclusive	Number of stations	Direction of major axis λ
1900–05	6	59° W
1906–11	6	90 W
1912–17	3	117 W
1910–15	4	75 W
1900–11	6	81 W
1900–17	3	110 W

The first three lines give results for each of the three six-year periods[17] into which the time covered by the observations is divided. The fourth line represents a series cutting across two other series and serves as a check. Other check results, not given here, were obtained and were all to the same general effect. The last two lines are mean results for the periods specified. A mean for the result of the entire discussion might be taken, somewhat arbitrarily perhaps, as 90° West. Helmert[18] has determined the same quantity from gravity observations, his result being 107° West. Since gravity can at present be observed satisfactorily only on land, that is, on one-fourth only of the Earth's surface, and since the influence on gravity of local topographic and geologic conditions is considerable, it is satisfactory to have even a rough agreement of the results from the two methods.

The amount of the difference between the principal equatorial moments, A and B, may be specified by giving the ratio

$$(B-A) \div [C-\tfrac{1}{2}(A+B)],$$

the letter C denoting the moment of inertia about the axis of rotation. Helmert finds for this ratio 1/46. The same ratio may be deduced from the eccentricity of the ellipse of polar motion; the results of this investigation point to a value of the same order of magnitude but apparently somewhat larger, perhaps 1/30 or 1/20, ratios which would follow from some of the gravity formulas which Helmert derives only to reject in favor of the formula leading to 1/46. From the ratio $(B-A \div [C-\tfrac{1}{2}(A+B)]$ we may deduce the difference between the greatest equatorial radius of the Earth and the least. For Helmert's ratio 1/46 this difference is 230 meters; for larger or smaller ratios the difference between the equatorial radii varies proportionally.

[17] The six-year length of series is particularly suitable for harmonic analysis.

[18] F. R. HELMERT. *Neue Formeln für den Verlauf der Schwerkraft im Meeresniveau beim Festlande.* Sitz.-Ber. kön. preuss. Akad. Wiss. **1915**: 676.

Since this ratio, like the direction of the major axis, is subject to a correction for the yielding of the ocean waters under the centrifugal force arising from the variation of latitude itself, no precise results are stated in this connection as the definitive results of the investigation until this correction can be investigated and applied. The important points are (1) that, contrary to Wanach's implied opinion, there is some prospect of getting information regarding the moments of inertia and the figure of the Earth out of the observations of the variation of latitude; and (2) that the results so far obtained confirm in a general way the results of Helmert from gravity observations.

The principal results of this investigation may be summed up as the prospect just mentioned of getting data on the figure of the Earth out of the latitude observations, and the conclusion previously discussed that the increase in latitude at Ukiah is due partly to the declinations used, being to that extent unreal, and partly due to a shifting of the North Pole towards the American continent.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts preferably prepared, and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to these appearing in this issue.

OCEANOGRAPHY.—*Tidal observations off the entrance to Delaware Bay.* H. A. MARMER. Journ. Franklin Inst. **191:** 819–821. 1921.

This paper discusses the results of a forty-hour series of offshore tidal observations made on Five Fathom Bank, about 18 nautical miles off the entrance to Delaware Bay, by a hydrographic party of the Coast and Geodetic Survey. Special interest attaches to this series of observations, because of its being made at some distance from the coast and also because of the simple and inexpensive tide gauge used. At present our knowledge of the time and range of the tide away from the coast is extremely meager, since tidal observations have been confined almost wholly to the immediate vicinity of the coast.

A description of the tide gauge inprovised for observing the height of the tide is described and the results compared with simultaneous tidal observations at Breakwater Harbor, Delaware, about 23 miles west of Five Fathom Bank. The cotidal hour as determined from these observations agrees well with the cotidal lines for this region constructed by Harris from theoretical considerations. H. A. M.

ORNITHOLOGY.—*Washington region [February and March, 1920].* H. C. OBERHOLSER. Bird Lore **22:** 167. 1920.

Notwithstanding a backward spring, birds appeared about Washington in about their usual numbers and at about their usual time during February and March, 1920. The European Starling (*Sturnus vulgaris vulgaris*) has become thoroughly established in the vicinity of Washington. Without

doubt the outstanding feature of interest was the astonishing number of ducks that frequented the Potomac River. The species most abundant were *Marila marila, Marila affinis, Anas rubripes,* and *Glaucionetta clangula americana.* Flocks of geese, *Branta canadensis canadensis,* and swans, *Olor columbianus,* were also present. H. C. O.

ORNITHOLOGY.—*Birds of the Clear Creek District, Colorado.* F. C. LINCOLN. Auk **37:** 607. 1920.

Systematic investigations in the region about Clear Creek near Denver, Colorado, during a period of five years have resulted in a list of 182 birds, including a number of rare species. H. C. OBERHOLSER.

ORNITHOLOGY.—*Relative abundance of wild ducks at Delavan, Wisconsin.* N. HOLLISTER. Auk **37:** 367–371. 1920.

Records of ducks obtained at Delavan, Wisconsin, during the years 1892 to 1899 give an interesting indication of the relative abundance of species during that period. A list is given showing the species observed in the order of their abundance. H. C. OBERHOLSER.

ORNITHOLOGY.—*Four new birds from the Philippines and Greater Sunda Islands.* J. H. RILEY. Proc. Biol. Soc. Wash. **33:** 55–58. 1920.

The following subspecies of East Indian birds are described: *Anthreptes malacensis paraguae,* from Palawan, Philippine Islands, *A. m. bornensis,* from British North Borneo; *Enodes erythrophrys centralis,* from Celebes; and *Munia punctulata particeps,* from Celebes. H. C. OBERHOLSER.

GEOLOGY.—*Oil prospects in Washington County, Utah.* HARVEY BASSLER and JOHN B. REESIDE, JR. U. S. Geol. Surv. Bull. **726**-C. Pp. 87–107. 1921.

Washington County, in extreme southwestern Utah, is drained by Virgin River, one of the larger tributaries of the Colorado. Exploratory drilling for oil has not been extensive in Washington County. Drilling near Virgin City resulted in several small wells as early as 1907.

The rocks of the region range in age from Mississippian to Tertiary, but those of greatest importance as possible sources of oil are the older rocks, beneath what is known as the Shinarump conglomerate. These older rocks are included in the Moenkopi formation, the Kaibab limestone, and a sandstone formation which represents the Coconino sandstone and Supai formation of the Grand Canyon area.

The region may be considered structurally as two districts separated by the Hurricane fault, which runs north and south on a line 15 miles east of St. George. East of the fault the rocks are relatively little disturbed. Some smaller faults and some low anticlines are present, but as a whole the district is one of low monoclinal dips without any large modifications. West of the Hurricane fault folds and smaller faults of various sizes have so greatly changed the original attitude of the rocks that the district is structurally complex in comparison with that east of the fault.

Nothing more was done in the field near Virgin City east of the Hurricane fault until 1918, when the three producing wells were cleaned out and shot, pumping was started, and a small local refinery was built. A new well was drilled near the old wells and has a production of 4 or 5 barrels a day. The total production from the four wells, which are uncased holes 550 to 600 feet

deep, is about 20 barrels a day (September, 1920). The bulk of this amount is coming from one well, the other wells pumping much more water than oil. The refinery will handle 800 gallons of crude oil per 8-hour shift, and the products find a ready local market.

The oil is reported to range in gravity from 25° to 35° Baumé, to have a paraffin base that includes some asphalt, and to contain some sulphur. The oil comes from a 1-foot bed of limestone which is at the top of the basal Rock Canyon conglomeratic member of the Moenkopi.

It seems most probable on the evidence presented that terraces, or areas of low dip, are favorable to the accumulation oil in this field and that the steep slopes are unfavorable. There are no anticlines, faults, or other features closely enough associated with the producing field to offer an explanation for the accumulation of oil, so that the only likely factor left is that of accumulation on a terrace.

The value of the region west of Hurricane fault as a possible producer of oil it is impossible, of course, to gage in advance of drilling. The region near St. George contains favorable structural features, and there are rocks in them capable of serving as reservoirs for oil. At certain places, there is evidence favorable to the assumption that these rocks carry some oil. Whether oil is actually present in these rocks in the anticlines and domes remains for the drill to determine.

The report closes with recommendations for drilling. H. W. STONE.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY

The 152nd regular meeting of the Botanical Society of Washington was held in the Assembly Hall of the Cosmos Club at 8 p.m., Tuesday, May 3, 1921. There were 32 present.

The meeting was called to order by President CHAMBLISS, after which the minutes of the last meeting were read and approved. The executive committee presented the names of Mr. A. J. BRUMAN, Mr. FRANK G. O'DONNELL and ROBERT CLAUDE WRIGHT as candidates for membership.

Dr. ROBERT F. GRIGGS of the National Geographic Society, MR. CHARLES G. WOODBURY, Director of the Bureau of Raw Products Research, National Canners' Association, and Mr. JOHN W. TAYLOR of the Office of Cereal Investigations of the Bureau of Plant Industry, whose names were presented at the April Meeting, were voted into the Society.

A letter from the Commission of Fine Arts to the Society in regard to the establishment of a National Botanic Garden on the Mount Hamilton tract was read.

Mr. PICTER moved that the Chair appoint a committee to represent the Society in furthering the Botanic Garden project. This was seconded, the motion put and carried. President CHAMBLISS later appointed on this committee the following:

Mr. DAVID G. FAIRCHILD, *Chairman*
Prof. L. G. CORBETT
Mr. F. V. COVILLE
Mr. WALTER T. SWINGLE
Mr. GEORGE B. SUDWORTH

The regular program of the evening followed:

PETER BISSET: *Roses for Garden Decoration* (illustrated).

The conditions suitable for best results in growing roses may be summarized. The location should be open to the sun from the East and South and protected from the West and North by trees, preferably evergreens. The soil must be well drained and should be enriched by the application of well-rotted manure, which should be thoroughly spaded in. Four pounds of bone meal should be added to each wheelbarrow load of soil.

Concerning varieties; the tea roses are very popular. The hybrid tea is probably the rose of the future for American gardens. Maman Cochet, a hardy tea rose, is well adapted to the climate of Washington. Of the hybrid perpetuals, Baroness de Rotheschild, Mrs. John Laing, Mad Gabriel Luzett, Ulrich Brunner, Paul Neyron and Frau Karl Druschke are among the most beautiful. The ramblers have their use and can transform an ugly fence or unsightly place into an attractive picture. Among the Rugosas, which come to us from China, the most attractive are Mrs. George Bruant, Blanch double de Coubert, with its semi-double flowers, and Alba semi-plenary and the hybrid Conrad F. Meyer. Hugonis is one of the latest arrivals—a new yellow rose.

Twenty-four varieties of roses are recommended for general garden culture:

Augustine Guinoisseau	Mme. Abel Chatenay
Caroline Testout	Mme. Hoste
Cecile Brunner	Mme. Jean Dupuy
Dean Hole	Maman Cochet
Fabvier	Marie van Houtte
Fisher Holmes	Mrs. John Laing
Florence Pemberton	Mrs. R. G. Sharmon-Crawford
Frau Karl Druschki	Rosette de la Legion d'Honneur
Gustave Grunerwald	Souvenir du President Carnot
Gustave Regis	Ulrich Brunner
Kaiserin Augusta Victoria	Victor Hugo
La France	White Maman Cochet

Dr. C. DWIGHT MARSH: *Poisonous Whorled Milkweeds* (illustrated).

Asclepias galioides, the whorled milkweed, is one of the most poisonous plants which has been investigated. This species is confined to Arizona, New Mexico, Colorado and Utah. Two to three ounces of a fresh plant of *A. galioides* will kill a sheep. The effects from eating are violent spasms, then death. High temperatures are reached in some animals in acute stages. This species is equally poisonous to sheep and horses but is not so poisonous to cattle, that is, with equal doses per hundred weight.

There are at least two toxic substances in plants: (1) a narcotic glucoside, (2) a spasmodic principle. These have been separated. Capillary congestion is caused in the organs of the animal, also degeneration in the organs. This is so serious that recovery rarely occurs.

Asclepias pumila is found on the plains in Eastern Colorado. Eating of these plants caused same symptoms in the animal as *A. galioides*, but the plant is not so toxic. The dosage is 4 times as great.

A. verticillata geyeri—Missouri Valley, Iowa. Animals eating this plant show same symptoms, but plant is still less toxic. Dosage 10 times as much. It is of little importance as a poisonous plant. Dosage 2 pounds per 100 lbs. plants.

A. mexicana is found in Nevada and California extending south into Mexico. Same symptoms—not as toxic about like pumila—dosage 4 times *galioides*.

All produce same effect on animals. *Galioides*—a dry land plant—spreads by seed and by roots—cultivation spreads plant.

Dr. ARNO VIEHOEVER: *Edible and Poisonous Beans of the Lima Type.—Phaseolus lunatus L.* (illustrated).

Beans of the lima type (*Phaseolus lunatus*) are rich in food essentials, carbohydrates, protein and fat. All varieties contain, in addition, the glucoside linamarin, yielding, like the amygdalin of bitter almonds, hydrocyanic acid when macerated with water. In domestic cultivated forms the amount of hydrocyanic acid is so small that the beans can be considered safe for consumption. The majority of samples obtained from tropical countries, however, were found to yield excessive amounts of the poisonous acid in different samples as well as in individual beans of the same sample. The amount of hydrocyanic acid found in the domestic lima beans ranged from a trace to the maximum of 10 mg. per 100 g. of beans. We obtained from the tropical beans quantities of hydrocyanic acid amounting to as much as 300 mg. and more in 100 g. of the material.

The large, uniformly white lima bean, grown on an extensive scale in California, and also imported from Madagascar, has been found harmless. Small lima beans cannot be considered as coming from a different species than the large lima beans. The most poisonous forms found were, however, beans of the small type.

The color does not differentiate the harmless from the poisonous forms, neither do the morphology or structure of the beans give safe means of separation and differentiation. There are, however, morphological and anatomical characteristics which permit the ready differentiation of beans of the lima type from beans of other types, one of the most striking means being the general absence of calcium oxalate in the seedcoat of *Phaseolus lunatus*.

Cooking of the poisonous beans does not render them harmless, although the boiling water will extract a portion of the compound yielding hydrocyanic acid.

The name "Lima Bean" should be limited to the edible forms.

ROY G. PIERCE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Forty-one Federal Government periodicals suspended publication on December 1, for lack of specific authorization from Congress for their continuance. Among the scientific and technical periodicals suspended are: *Experiment Station Record; Journal of Agricultural Research; Monthly Weather Review;* and *Public Roads*.

The Petrologists' Club met at the home of H. G. FERGUSON on December 20, and discussed the following topics: E. B. SAMPSON: *Origin of serpentine in the lime type of asbestos deposits;* S. H. CATHCART: *Review of W. N. Benson's "Origin of serpentine;"* C. S. ROSS and E. V. SHANNON: *Iddingsite as a deuteric mineral.*

The National Museum reports the receipt of a fragment of a heretofore unknown meteorite (a pallasite) from Cold Bay, western Alaska. The entire mass as found was in the form of a badly oxidized mass of but a few pounds weight, which was at once broken up by the finders and in large part lost. The find is the second from Alaska proper, the first having been that of Chilkat (an iron).

The Bureau of Standards announces that a considerable improvement has been noted in the quality of American analytical weights. A number of sets have been received recently in which every weight was within the prescribed tolerances, while four recent sets of foreign weights showed 20 to 32 per cent of the weights outside the tolerances.

A dinner was given at the Cosmos Club on Friday night, December 16, by the officers of the ACADEMY and the Chemical Society in honor of Prof. JACQUES CAVALIER, recteur of the University of Toulouse and Exchange Professor at a group of American universities. The dinner followed a lecture by Prof. Cavalier at the Bureau of Standards in the afternoon, on *Les industries chimiques en France pendant la Guerre.*

Dr. BARTON W. EVERMANN, at one time with the U. S. Fish Commission in Washington, and a former editor of the *Proceedings* and of the *Journal* of the ACADEMY, has been appointed director of the new Steinhart Aquarium of the California Academy of Sciences at San Francisco, California.

A course of ten lectures on applied anthropology is being given by Dr. ALES HRDLICKA, of the National Museum, under the joint auspices of the Educational Department of the Young Men's Christian Association and the Institute of Vocational Research of Washington.

Dr. W. J. HUMPHREYS of the Weather Bureau lectured before the Physics Club of the Bureau of Standards on November 28, on *The temperature and other conditions of the free air.*

Dr. FRANZ AUGUST RICHARD JUNG, a practicing physician in Washington, and a resident member of the ACADEMY since 1902, died at his home at 1868 Columbia Road on December 16, 1921, in his fifty-third year. Dr. Jung was born in Thuringia, Germany, October 9, 1869. He came to the United States in 1896, and took up the practice of his profession in Washington in collaboration with his wife, Dr. SOFIE A. NORDHOFF-JUNG. They were in Munich when the War began in 1914, and opened there an American Red Cross Hospital, which was closed in 1917 when the United States entered the War. Dr. Jung was a member of the ACADEMY and the Medical Society, and was a frequent contributor to the medical journals, especially on subjects related to digestion and assimilation.

Mr. S. KRUSE, associate electrical engineer at the Bureau of Standards, who has been engaged in radio development work at the Bureau, has been granted a year's leave of absence and has accepted a position with the Hammond Radio Research Corporation, Gloucester, Massachusetts.

Mr. A. A. STEVENSON, chairman of the American Engineering Standards Committee, spoke before the Washington Section of the American Society of Mechanical Engineers on December 9 on *The significance of standardization to industry and the Federal Government.*

Dr. RAYMOND W. WOODWARD has resigned as physicist and chief of the section of mechanical metallurgy of the Bureau of Standards, to becomec hief metallurgist for the Whitney Manufacturing Company of Hartford, Connecticut.